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$$\begin{vmatrix} \alpha & \beta & \gamma \\ \gamma & \alpha & \beta \\ \beta & \gamma & \alpha \end{vmatrix} = \begin{vmatrix} a & b & c \\ c & a & b \\ b & c & a \end{vmatrix} \cdot \begin{vmatrix} x & y & z \\ z & x & y \\ y & z & x \end{vmatrix}.$$

Also solved by J. B. Faught, G. B. M. Zerr, G. W. Greenwood, Grace M. Bareis, J. O. Mahoney, F. D. Posey, F. O. Whitlock, J. Scheffer.

⁂ Dr. L. E. Dickson points out that a similar theorem holds for any determinant whose matrix is the body of a multiplication-table of a finite group.

GEOMETRY.

251. Proposed by R. D. CARMICHAEL, Hartselle, Ala.

Represent the vertices of any regular polygon by the consecutive numbers 1, 2....p.....q.....r.....n. To find the sides and area of the triangle formed by joining p, q, and r.

Solution by G. W. GREENWOOD, M. A. (Oxon), Lebanon, Ill., and A. H. HOLMES, Brunswick, Me.

The central angles subtended by the chords (pq) and (qr) are respectively,

$$2(q-p)\frac{\pi}{n} \text{ and } 2(r-q)\frac{\pi}{n}.$$

The angle pqr is found to be $\pi-(r-p)\dfrac{\pi}{n}$. Hence the required area is

$$\tfrac{1}{2}.pq.qr.\sin\angle pqr=2a^2\sin(q-p)\frac{\pi}{n}.\sin(r-q)\frac{\pi}{n}.\sin(r-p)\frac{\pi}{n},$$

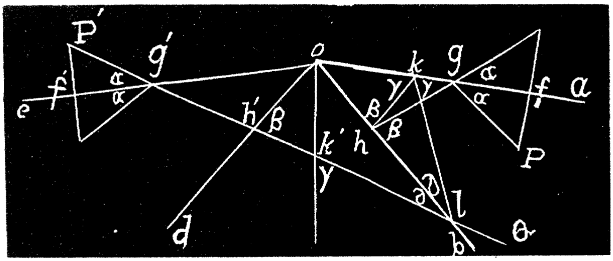
where a is the radius of the circum-circle of the polygon.

252. Proposed by FREDERICK R. HONEY, Ph. B., Trinity College, Hartford, Conn.

Two plane mirrors form an angle which is less than 45°. Any two points are assumed within this angle in a plane perpendicular to the intersection of the mirrors. A ray of light passes through one point, and after being reflected twice at each mirror, it passes through the second point. Find the path of the ray.

Solution by R. A. WELLS, Westminster College, Fulton, Mo.; THEODORE LINQUIST, Wahpeton, N. D.; and the PROPOSER.

Let oa and ob represent the mirrors; and P and Q the assumed points. Draw oc, od, and oe, making each of the angles boc, cod, and doe equal to aob. Draw Pf perpendicular to oa. Make $of'=of$; and draw $f'P'$ perpendicular to oe and equal to Pf. Draw QP', intersecting ob at l, oc at k', od at h', and oe at g'. Make $og=og'$; $oh=oh'$; $ok=ok'$. Join Pg, gh, hk, and kl. $PghklQ$ is the path of the ray.



The Greek letters indicate the equality of certain angles, and will assist the reader in the demonstration.

Also solved by G. W. Greenwood.

The following contributors sent in solutions to this department too late for credit in the last issue: G. B. M. Zerr solved 245; Theodore Linquist, 248 and 249; A. H. Holmes, 248, 249, and 250.

253. Proposed by **SAM I. JONES**, Gunter Bible College, Gunter, Texas.

The number of cubic inches contained by two equal opposite spherical segments, together with the number of cubic inches contained by the cylinder included between these segments, is 600; if this be $\frac{2}{3}$ of the number of cubic inches contained by the whole sphere, find the height of the cylinder.

Solution by **THEODORE LINQUIST**, Wahpeton, N. Dak.; **G. W. GREENWOOD, M. A.** (Oxon), Lebanon, Ill., and **A. H. HOLMES**, Brunswick, Me.

Let R=the radius of the sphere, and $2h$ the altitude of the cylander. Then $R-h$=the altitude of the segment of the sphere, and $\sqrt{(R^2-h^2)}$ is the radius of the base of the segment and the radius of the cylinder.

The volume of the two segments$=2[\frac{1}{6}\pi(R-h)^3+\frac{1}{2}\pi(R-h)(R^2-h^2)]$, and the volume of cylinder$=2\pi h(R^2-h^2)$.

$\therefore\frac{4}{3}\pi(R^3-h^3)$=the volume of the segments, and the cylinder$=\frac{2}{3}(\frac{4}{3}\pi R^3)$, by the conditions of the problem.

$\therefore 3h^3=R^3$. $\therefore\frac{4}{3}\pi(R^3-h^3)=\frac{8}{3}\pi h^3=600$, by the conditions of the problem.

$\therefore 2h=2\sqrt[3]{(225/\pi)}$.

Also solved by J. Scheffer.

CALCULUS.

191. Proposed by **J. E. SANDERS**, Hackney, Ohio.

A fly goes along a radius of a moving carriage wheel from center to circumference while the wheel makes n revolutions. If each move uniformly, what is the equation to the curve described by the fly in space, and what is its length when the wheel has made $1/m$ of a revolution?

Solution by **G. W. GREENWOOD, M. A.** (Oxon), Professor of Mathematics, McKendree College, Lebanon, Ill.

Take the path of the center of the wheel as x-axis, and the initial point as origin. Let the fly move on a radius making, initially, an angle ϕ with this axis. Denote the radius by a. Let C be the position of the center of the wheel, and P be that of the fly after the wheel has turned through an angle ω. Then

$$OC=a\omega,\ CP=\frac{a\omega}{2n\pi},$$

and the coördinates of the position of P are

$$x=a\omega\left(1+\frac{\cos(\omega+\phi)}{2n\pi}\right),\ y=\frac{a\omega\sin(\omega+\phi)}{2n\pi}.$$